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CLAIMS AMENDMENTS

Please amend claims 1 and 62. Please add new claims 36 and 96, which effectively reinstate with some amendment, earlier versions of these same-numbered claims that were cancelled in applicants' July 19, 2005 reply. All other claims are unchanged.

1 1. (currently amended) A system for identifying and measuring
2 concentrations of elements in fluids, comprising:
3 an ionic preconcentration cell, comprising:
4 an upper high surface area electrode comprising a high
5 specific surface area thereof;
6 a lower high surface area electrode comprising a high
7 specific surface area thereof, substantially parallel to
8 said upper high surface area electrode;
9 a central flow interelectrode gap separating said upper
10 and lower high surface area electrodes by a predetermined
11 interelectrode gap width; and
12 fluid flow means for flowing a fluid through said
13 central flow interelectrode gap;~~and~~
14 a computerized apparatus comprising calibration data related
15 to a rate at which photons are detected to be emitted from said
16 preconcentration cell based on a fluid of interest containing a
17 known concentration of at least one element of interest being
18 flowed at a known flow rate through said central flow
19 interelectrode gap for a known period of time, a known voltage
20 differential being applied across said electrodes, and said
21 preconcentration cell being exposed to x-rays; and
22 said computerized apparatus deducing an identity, or

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23 measurement of concentration, of an unknown concentration of said
24 at least one element of interest in said fluid of interest, based
25 on comparing said calibration data with test data related to a
26 rate at which photons are detected to be emitted from said
27 preconcentration cell based on said fluid of interest with said
28 unknown concentration being flowed at a known flow rate through
29 said central flow interelectrode gap for a known period of time,
30 a known voltage differential being applied across said
31 electrodes, and said preconcentration cell being exposed to x-
32 rays.

33 ~~calibration data comprising background data related to a~~
34 ~~rate at which photons are detected to be emitted from at least~~
35 ~~one background data energy channel of said preconcentration cell~~
36 ~~or an equivalent cell, when said preconcentration cell or~~
37 ~~equivalent cell is filled with a highly purified form of a fluid~~
38 ~~of interest and exposed to x-rays.~~

1 2. (original) The system of claim 1, further comprising:

2 voltage application means for applying a voltage
3 differential between said upper high surface area electrode and
4 said lower high surface area electrode while said fluid is
5 flowing through said central flow interelectrode gap.

1 3. (previously presented) The system of claim 2, said voltage
2 application means further comprising:

3 a transportable voltage supply connected across said upper
4 and lower high surface area electrodes for applying an
5 electrostatic charge across said electrodes and thereby
6 maintaining ions from said at least one element entrained in said

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7 electrodes during transport of said ionic preconcentration cell.

1 4. (previously presented) The system of claim 1, said ionic
2 preconcentration cell further comprising:

3 an upper x-ray transmission window in intimate contact with
4 an upper surface of said upper high surface area electrode.

1 5. (previously presented) The system of claim 4, said ionic
2 preconcentration cell further comprising:

3 a lower x-ray transmission window in intimate contact with a
4 lower surface of said lower high surface area electrode.

1 6. (original) The system of claim 1, said ionic
2 preconcentration cell further comprising:

3 inlet flow means for entering a fluid into said ionic
4 preconcentration cell and enabling said fluid to flow through
5 said central flow interelectrode gap.

1 7. (previously presented) The system of claim 6, said inlet
2 flow means comprising at least one planar inlet flow slot
3 substantially coplanar with said central flow interelectrode gap.

1 8. (previously presented) The system of claim 6, said inlet
2 flow means comprising a plurality of mutually-substantially
3 coplanar inlet flow tubes substantially coplanar with said
4 central flow interelectrode gap and substantially parallel with
5 one another.

1 9. (previously presented) The system of claim 6, said inlet
2 flow means comprising turbulence enhancement means for enhancing
3 a turbulence of the flow of said fluid to induce mixing of said
4 flow to enable uniform extraction of said at least one element
5 from the flow stream.

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1 10. (previously presented) The system of claim 6, said inlet
2 flow means comprising access means for accessing said inlet flow
3 means for physically cleaning debris therefrom.

1 11. (original) The system of claim 1, said ionic
2 preconcentration cell further comprising:

3 outlet flow means for exiting said fluid out from said ionic
4 preconcentration cell after said fluid has flowed through said
5 central flow interelectrode gap.

1 12. (previously presented) The system of claim 11, said
2 outlet flow means comprising at least one outlet flow slot
3 substantially coplanar with said central flow interelectrode gap.

1 13. (previously presented) The system of claim 11, said
2 outlet flow means comprising a plurality of outlet flow tubes
3 substantially coplanar with said central flow interelectrode gap
4 and substantially parallel with one another.

1 14. (previously presented) The system of claim 11, said
2 outlet flow means comprising access means for accessing said
3 outlet flow means for physically cleaning debris therefrom.

1 15. (previously presented) The system of claim 4, said ionic
2 preconcentration cell further comprising:

3 a cell collector body maintaining a position of said upper
4 and lower high surface area electrodes and said upper x-ray
5 transmission window relative to one another, said cell collector
6 body in turn comprising a material comprising:

7 substantially no conductivity;

8 resistance to ionic leaching; and

9 resistance to radiation degradation from x-rays to

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10 which said preconcentration cell is to be exposed.

1 16. (previously presented) The system of claim 4, said ionic
2 preconcentration cell further comprising:

3 a cell collector body maintaining a position of said upper
4 and lower high surface area electrodes and said upper x-ray
5 transmission window relative to one another, said cell collector
6 body comprising a material selected from a material group
7 consisting of: plastic, glass, and fiberglass.

1 17. (previously presented) The system of claim 4, said ionic
2 preconcentration cell further comprising:

3 a cell collector body maintaining a position of said upper
4 and lower high surface area electrodes and said upper x-ray
5 transmission window relative to one another, said cell collector
6 body comprising a non-conducting, machinable polymer
7 substantially resistant to radiation degradation.

1 18. (previously presented) The system of claim 1:
2 said upper high surface area electrode further comprising an
3 upper electrode thickness less than or equal to approximately $\ell =$
4 $1/(\mu * \rho)$, wherein:

5 ℓ designates an optical depth of said upper high surface
6 area electrode when wetted with an element of interest for which
7 a fluidic concentration is to be measured, in said fluid;

8 μ designates a mass absorption coefficient of said upper
9 high surface area electrode when wetted with said element of
10 interest in said fluid; and

11 ρ designates a material density of said upper high surface

12 area electrode when wetted with said element of interest in said
13 fluid.

1 19. (previously presented) The system of claim 18:

2 said lower high surface area electrode further comprising a
3 lower electrode thickness less than or equal to approximately $\ell =$
4 $1/(\mu * p)$, wherein:

5 ℓ designates an optical depth of said lower high surface
6 area electrode when wetted with an element of interest for which
7 a fluidic concentration is to be measured, in said fluid;

8 μ designates a mass absorption coefficient of said lower
9 high surface area electrode when wetted with said element of
10 interest in said fluid; and

11 p designates a material density of said lower high surface
12 area electrode when wetted with said element of interest in said
13 fluid.

1 20. (original) The system of claim 1, said upper high surface
2 area electrode and said lower high surface area electrode further
3 comprising an ordinary surface area approximately equal to an
4 interrogation spot area of x-rays to which said preconcentration
5 cell is to be exposed.

1 21. (previously presented) The system of claim 4, said upper
2 x-ray transmission window comprising a surface area approximately
3 equal to an interrogation spot area of x-rays to which said
4 preconcentration cell is to be exposed.

1 22. (previously presented) The system of claim 2, said
2 central flow interelectrode gap comprising said predetermined

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3 interelectrode gap width, designated d , within an interelectrode
4 gap range specified by:

5
$$d = \frac{\sigma \Phi w_i}{q \epsilon w_f n_f C F} \times 100\% \approx 2 \times 10^{-9} \frac{\Phi w_i A}{q \epsilon w_f n_f F} \times 100\% \propto \frac{\Phi A}{\epsilon F}, \text{ wherein:}$$

6 ϵ designates a predetermined percentage of at least one
7 element of interest to be extracted from said fluid, σ designates
8 a composite conductivity of said fluid, Φ designates a potential
9 applied by said voltage application means across said electrodes,
10 $q = 1.60 \times 10^{-19}$ Coulomb designates the unit charge, A designates an
11 ordinary surface area covered by said electrodes, n_f designates a
12 number density of said fluid, w_i and w_f designate atomic /
13 molecular weights, respectively, of said at least one element of
14 interest and of said fluid, C designates a concentration of said
15 at least one element of interest in said fluid, and F designates
16 a flow rate of said fluid through said ionic preconcentration
17 cell;

18 said high surface area electrodes further comprise said
19 ordinary surface area A approximately equal to an interrogation
20 spot area of x-rays to which said preconcentration cell is to be
21 exposed;

22 said ϵ is chosen to be below approximately 5% for said at
23 least one element of interest;

24 said Φ is chosen to be below an electrochemical potential of
25 said at least one element of interest and below an electrolysis
26 potential of said fluid;

27 said F is chosen to exert no more than approximately .1 atm

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28 of pressure upon an upper x-ray transmission window of said ionic
29 preconcentration cell in intimate contact with an upper surface
30 of said upper high surface area electrode;

31 said n_f and said w_f are chosen with reference to said at
32 least one element of interest; and

33 said w_i is chosen with reference to said fluid.

1 23. (previously presented) The system of claim 22, said
2 central flow interelectrode gap comprising said predetermined
3 interelectrode gap width, d , with:

4 a minimum gap width selected from a minimum gap width group
5 consisting of 2 mm, 1 mm, .5 mm, and .25 mm; and

6 a maximum gap width selected from a maximum gap width group
7 consisting of 2 mm, 5 mm, and 10 mm.

1 24. (previously presented) The system of claim 4, said upper
2 x-ray transmission window comprising:

3 an atomic number below 10;

4 structural rigidity to support up to 1/10 atm. of pressure
5 without bowing more than approximately 100 microns;

6 substantial impermeability relative to said fluid;

7 x-ray transparency greater than 90% for characteristic
8 photon energies from an element of interest for which a fluidic
9 concentration is to be measured;

10 x-ray scattering therefrom minimized to less than
11 approximately 10% of radiation scattered from a column of said
12 fluid equal to one optical depth in said fluid of a
13 characteristic photonic energy from an element of interest for
14 which a fluidic concentration is to be measured; and

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15 freedom from any single contaminant in excess of 1 part per
16 million, when measured by x-ray fluorescence.

1 25. (previously presented) The system of claim 5, said lower
2 x-ray transmission window comprising:

3 an atomic number below 10;
4 structural rigidity to support up to 1/10 atm. of pressure
5 without bowing more than approximately 100 microns;
6 substantial impermeability relative to said fluid;
7 x-ray transparency greater than 90% for characteristic
8 photon energies from an element of interest for which a fluidic
9 concentration is to be measured;

10 x-ray scattering therefrom minimized to less than
11 approximately 10% of radiation scattered from a column of said
12 fluid equal to one optical depth in said fluid of a
13 characteristic photonic energy from an element of interest for
14 which a fluidic concentration is to be measured; and

15 freedom from any single contaminant in excess of 1 part per
16 million, when measured by x-ray fluorescence.

1 26. (previously presented) The system of claim 4, said upper
2 x-ray transmission window comprising a polyimide film comprising
3 structural rigidity to support up to 1/10 atm. of pressure
4 without bowing more than approximately 100 microns.

1 27. (previously presented) The system of claim 5, said lower
2 x-ray transmission window comprising a polyimide film comprising
3 structural rigidity to support up to 1/10 atm. of pressure
4 without bowing more than approximately 100 microns.

1 28. (previously presented) The system of claim 1:

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2 said upper high surface area electrode and said lower high
3 surface area electrode each comprising a high surface area
4 material in turn comprising:

5 a large plurality of pores characterized by a specific
6 surface area of at least approximately 100 m²/g;

7 an average pore diameter of said pores between approximately
8 30 nm and 10 nm per pore;

9 a distribution of the pore diameters grouped with a standard
10 deviation of less than approximately 10nm around said average
11 pore diameter;

12 an x-ray transparency greater than approximately 90% for
13 characteristic photon energies from an element of interest for
14 which a fluidic concentration is to be measured;

15 electrical conductivity of 10-40 mOhms-cm when fabricated
16 into a ¼ mm thick electrode;

17 the ability to contain approximately at least 0.1% by weight
18 of foreign material relative to said high surface area material
19 prior to saturation;

20 high structural rigidity wherein a displacement under the
21 flow of said fluid does not exceed approximately 0.25mm;

22 high wetting ability wherein an approximately ¼ mm thick
23 sheet of said high surface area material becomes substantially
24 wetted in less than approximately three seconds; and

25 freedom from metallic impurities in excess of approximately
26 .5 parts per million, when measured by x-ray fluorescence
27 analysis.

1 30. (previously presented) The system of claim 28, said large
2 plurality of pores characterized by a specific surface area of at
3 most approximately 1000 m²/g.

1 31. (previously presented) The system of claim 29, said large
2 plurality of pores characterized by a specific surface area of at
3 most approximately 1000 m²/g.

1 32. (previously presented) The system of claim 1, said upper
2 high surface area electrode and said lower high surface area
3 electrode each comprising a high surface area material in turn
4 comprising:

5 an x-ray transparency greater than approximately 90% for
6 characteristic photon energies from an element of interest for
7 which a fluidic concentration is to be measured.

1 33. (original) The system of claim 1, said upper high surface
2 area electrode and said lower high surface area electrode each
3 comprising a carbon aerogel.

1 34. (previously presented) The system of claim 1, said upper
2 high surface area electrode comprising a thickness less than
3 approximately $\ell = 1/(\mu * \rho)$; wherein:

4 ℓ designates an optical depth of said upper high surface
5 area electrode when wetted with said fluid;

6 μ designates a mass absorption coefficient of said high
7 surface area electrode when wetted with said fluid; and

8 ρ designates a density of said high surface area electrode

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9 when wetted with said fluid.

1 35. (previously presented) The system of claim 34, said lower
2 high surface area electrode comprising a thickness less than
3 approximately $\ell = 1/(\mu * \rho)$; wherein:

4 ℓ designates an optical depth of said lower high surface
5 area electrode when wetted with said fluid;

6 μ designates a mass absorption coefficient of said lower
7 surface area electrode when wetted with said fluid; and

8 ρ designates a density of said lower surface area electrode
9 when wetted with said fluid.

1 36. (new) The system of claim 1, said calibration data
2 further comprising:

3 background data comprising data related to a rate at which
4 photons are detected to be emitted from at least one background
5 data energy channel of said preconcentration cell, when said
6 preconcentration cell is filled with a highly purified form of a
7 fluid of interest and exposed to x-rays.

1 37. (previously presented) The system of claim 1, said
2 calibration data further comprising:

3 sensitivity data related to a rate at which photons are
4 detected to be emitted from at least one sensitivity data energy
5 channel of said preconcentration cell, when said preconcentration
6 cell is filled with a first calibration solution, containing at
7 least one element of interest in a fluid of interest in known
8 concentration above a minimum detection level of x-ray detection
9 equipment to be used for said detecting and measuring, and when
10 said preconcentration cell is exposed to x-rays.

1 38. (previously presented) The system of claim 2, said
2 calibration data further comprising:
3 ion extraction rate data related to a rate at which photons
4 are detected to be emitted from at least one ion extraction rate
5 data energy channel of said preconcentration cell, when a
6 calibration solution, containing said at least one element of
7 interest in a fluid of interest in known concentration below a
8 minimum detection level of x-ray detection equipment to be used
9 for said detecting and measuring, is flowed through the central
10 flow interelectrode gap of said preconcentration cell, at a
11 substantially constant flow rate, while the voltage application
12 means applies the voltage differential across the electrodes of
13 said preconcentration cell, below an electrochemical potential of
14 said at least one element of interest and below an electrolysis
15 potential of said calibration solution, and when said
16 preconcentration cell is exposed to x-rays.

1 39. (previously presented) The system of claim 2, said
2 calibration data further comprising:
3 background data related to a rate at which photons are
4 detected to be emitted from at least one background data energy
5 channel of said preconcentration cell, when said preconcentration
6 cell is filled with a highly purified form of a fluid of interest
7 and exposed to x-rays;
8 sensitivity data related to a rate at which photons are
9 detected to be emitted from at least one sensitivity data energy
10 channel of said preconcentration cell, when said preconcentration
11 cell is filled with a first calibration solution, containing at

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12 least one element of interest in said fluid of interest in known
13 concentration above a minimum detection level of x-ray detection
14 equipment to be used for said detecting and measuring, and when
15 said preconcentration cell is exposed to x-rays; and
16 ion extraction rate data related to a rate at which photons
17 are detected to be emitted from at least one ion extraction rate
18 data energy channel of said preconcentration cell, when a second
19 calibration solution, containing said at least one element of
20 interest in said fluid of interest in known concentration below
21 said minimum detection level of x-ray detection equipment to be
22 used for said detecting and measuring, is flowed through the
23 central flow interelectrode gap of said preconcentration cell, at
24 a substantially constant flow rate, while the voltage application
25 means applies the voltage differential across the electrodes of
26 said preconcentration cell, below an electrochemical potential of
27 said at least one element of interest and below an electrolysis
28 potential of said second calibration solution, and when said
29 preconcentration cell is exposed to x-rays.

1 40. (previously presented) The system of claim 2, further
2 comprising:

3 test data accumulation means for obtaining said test data
4 comprising data related to a rate at which photons are detected
5 to be emitted from at least one energy channel of said
6 preconcentration cell when said fluid, suspected to contain at
7 least one element of interest, is flowed through said central
8 flow interelectrode gap at a substantially constant flow rate,
9 while said voltage application means applies said voltage

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10 differential across said electrodes below an electrochemical
11 potential of said at least one element of interest and below an
12 electrolysis potential of said fluid, and when said
13 preconcentration cell is exposed to x-rays.

1 41. (original) The system of claim 40, further comprising:
2 analysis means for analyzing said test data and deducing
3 therefrom a concentration in said fluid, if any, of the suspected
4 at least one element of interest.

1 42. (previously presented) The system of claim 39, further
2 comprising:
3 test data accumulation means for obtaining said test data
4 comprising data related to a rate at which photons are detected
5 to be emitted from at least one energy channel of said
6 preconcentration cell when said fluid, suspected to contain at
7 least one element of interest, is flowed through said central
8 flow interelectrode gap at a substantially constant flow rate,
9 while said voltage application means applies said voltage
10 differential across said electrodes below an electrochemical
11 potential of said at least one element of interest and below an
12 electrolysis potential of said fluid, and when said
13 preconcentration cell is exposed to x-rays.

1 43. (original) The system of claim 42, further comprising:
2 analysis means for analyzing said test data in relation to
3 said background data, said sensitivity data, and said ion
4 extraction rate data, and deducing therefrom a concentration in
5 said fluid, if any, of the suspected at least one element of
6 interest.

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1 44. (previously presented) The system of claim 4, further
2 comprising:

3 voltage application means for applying a voltage
4 differential between said upper high surface area electrode and
5 said lower high surface area electrode while said fluid is
6 flowing through said central flow interelectrode gap; and
7 x-ray source means positioned and aligned relative to said
8 upper x-ray transmission window for exposing said
9 preconcentration cell to x-rays substantially transmitted through
10 said upper x-ray transmission window, while flowing said fluid
11 and while applying said voltage differential.

1 45. (previously presented) The system of claim 2, said
2 voltage application means further comprising:

3 a transportable voltage supply for applying an electrostatic
4 charge across said electrodes and thereby maintaining ions from
5 said at least one element entrained in said electrodes during
6 transport of said ionic preconcentration cell: after ceasing flow
7 of said fluid, while transporting said ionic preconcentration
8 cell to an x-ray source means for emitting x-rays toward said
9 preconcentration cell, and while exposing said preconcentration
10 cell to x-rays.

1 46. (original) The system of claim 1, further comprising:

2 flow control means for controlling a flow rate of said fluid
3 through said ionic preconcentration cell so as to maintain ϵ ,
4 which designates a predetermined percentage of at least one
5 element of interest to be extracted from said fluid, below
6 approximately 5% for said at least one element of interest.

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1 47. (previously presented) The system of claim 46, wherein
2 said ε is maintained below an extraction percentage selected from
3 an extraction percentage group consisting of approximately 4%,
4 3%, 2%, and 1%.

1 48. (previously presented) The system of claim 2, further
2 comprising flow control means for:
3 controlling a flow rate F of said fluid through said ionic
4 preconcentration cell and maintaining said F at a substantially
5 constant level so as to maintain ε , which designates a
6 predetermined percentage of at least one element of interest to
7 be extracted from said fluid and is specified by:

8
$$\varepsilon = \frac{\Gamma_{ie}}{\Gamma_{is}} = \frac{\sigma \Phi w_i}{q d w_f n_f C F} \times 100\%,$$

9 below approximately 5% for said at least one element of interest;
10 wherein:

11 Γ_{ie} and Γ_{is} designate rates at which ions of said at least
12 one element of interest are respectively extracted from said
13 fluid by said cell and supplied to said cell by said fluid, σ
14 designates a composite conductivity of said fluid, Φ designates
15 a potential applied by said voltage application means across said
16 electrodes, d designates said predetermined interelectrode gap
17 width of said central flow interelectrode gap, $q = 1.60 \times 10^{-19}$
18 Coulomb designates the unit charge, A designates an ordinary
19 surface area covered by said electrodes, n_f designates a number
20 density of said fluid, w_i and w_f designate atomic / molecular
21 weights, respectively, of said at least one element of interest
22 and of said fluid, and C designates a concentration of said at

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23 least one element of interest in said fluid; and
24 for having said concentration C in a range where
25 conductivity varies substantially linearly with concentration,
26 with C in units of parts per billion, wherein σ is approximated
27 by:

28 $\sigma \approx 2 \times 10^{-9} C / \text{Ohm} - \text{cm} .$

1 49. (previously presented) The system of claim 48, wherein
2 said ϵ is maintained below an extraction percentage selected from
3 an extraction percentage group consisting of approximately 4%,
4 3%, 2%, and 1%.

1 50. (original) The system of claim 2, said voltage
2 application means applying said voltage differential across said
3 electrodes below an electrochemical potential of at least one
4 element of interest and below an electrolysis potential of said
5 fluid.

1 51. (previously presented) The system of claim 1, further
2 comprising:
3 leakage current monitoring means for monitoring a total non-
4 saturated concentration of dissolved ions in said upper and lower
5 high surface area electrodes, by monitoring a leakage current
6 from said cell.

1 52. (previously presented) The system of claim 51, further
2 comprising:
3 ultra-low trace measuring means for measuring at least one
4 element of interest comprising ultra-low trace, high valence ions
5 in said fluid, based on said detecting the non-saturated
6 saturation state.

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1 53. (previously presented) The system of claim 1, further
 2 comprising:
 3 leakage current monitoring means for monitoring a total non-
 4 saturated concentration of dissolved ions in said upper and lower
 5 high surface area electrodes; and
 6 flow rate adjustment means for adjusting the flow of said
 7 fluid through said ionic preconcentration cell to control a
 8 percentage of said ions extracted from said fluid, based on said
 9 monitoring of said leakage current by said leakage current
 10 monitoring means.

1 54. (previously presented) The system of claim 1, further
 2 comprising:
 3 time control means for controlling how long said fluid flows
 4 through said ionic preconcentration cell based on setting an
 5 impurity concentration C , in a range where conductivity varies
 6 substantially linearly with concentration, to a predetermined
 7 desired concentration detection level and flowing said fluid for
 8 a time t given by:

9
$$t \propto \frac{Sl}{\sigma} \propto \frac{Sl}{C}; \text{ wherein:}$$

10 S designates a sensitivity of x-ray detection equipment to
 11 be used for said detecting and measuring;

12 l designates a thickness of said upper high surface area
 13 electrode; and

14 σ designates a composite conductivity of said fluid.

1 55. (previously presented) The system of claim 1, further
 2 comprising triggering means for triggering an action in response

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3 to said system detecting that a concentration of at least one
4 element of interest in said fluid has passed a predetermined,
5 non-saturated threshold concentration.

1 56. (previously presented) The system of claim 55, further
2 comprising injection action means for injecting at least one
3 element into said fluid, thereby maintaining said concentration
4 within a predetermined concentration range, as said action in
5 response to said triggering means.

1 57. (previously presented) The system of claim 55, further
2 comprising dilution action means for diluting at least one
3 diluting fluid into said fluid, thereby maintaining said
4 concentration within a predetermined concentration range, as said
5 action in response to said triggering means.

1 58. (previously presented) The system of claim 1, further
2 comprising:

3 ionic release means for cleaning said preconcentration cell
4 after use by releasing ions accumulated within said high specific
5 surface area of said electrodes into said fluid, after the
6 accumulated ions have been exposed to x-rays and fluorescence
7 from said preconcentration cell has been detected.

1 59. (previously presented) The system of claim 4, further
2 comprising:

3 x-ray source means positioned and aligned relative to said
4 upper x-ray transmission window for emitting x-rays toward said
5 preconcentration cell substantially transmitted through said
6 upper x-ray transmission window; and

7 x-ray fluorescence detector means positioned and aligned

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8 relative to said upper x-ray transmission window for detecting
9 fluoresced energy emitted by said preconcentration cell due to
10 said emitting x-rays toward said preconcentration cell, through
11 said upper x-ray transmission window.

1 60. (previously presented) The system of claim 59, further
2 comprising:

3 x-ray fluorescence analysis means for analyzing the detected
4 x-ray fluoresced energy and deducing therefrom a concentration in
5 said fluid of at least one element of interest in said fluid.

1 61. (previously presented) The system of claim 1, further
2 comprising:

3 a telecommunications link for downloading and analyzing said
4 test data from said ionic preconcentration cell.

1 62. (previously presented) A method for identifying and
2 measuring concentrations of elements in fluids, comprising the
3 steps of:

4 flowing a fluid through a central flow interelectrode gap of
5 an ionic preconcentration cell separating an upper high specific
6 surface area electrode from a lower high specific surface area
7 electrode of said ionic preconcentration cell by a predetermined
8 interelectrode gap width;

9 applying a known voltage differential between said upper
10 high surface area electrode and said lower high surface area
11 electrode while said fluid is flowing through said central flow
12 interelectrode gap;

13 exposing said cell to x-rays; ~~and under test conditions and~~
14 ~~obtaining test data characterizing a response thereto of said~~

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15 ~~cell; and~~
16 ~~— deducing an identity, or measurement of concentration, of at~~
17 ~~least one element in said fluid, using said test data in~~
18 ~~combination with calibration data,~~
19 deducing an an identity, or measurement of concentration, of
20 an unknown concentration of at least one element of interest in
21 said a fluid of interest, based on comparing calibration data
22 with test data related to a rate at which photons are detected to
23 be emitted from said preconcentration cell based on said fluid of
24 interest with said unknown concentration flowing through said
25 central flow interelectrode gap at a known flow rate for a known
26 period of time together with said applying said known voltage
27 differential and said exposing said cell to x-rays, wherein said
28 calibration data is obtained by:
29 flowing a fluid of interest containing a known concentration
30 of at least one element of interest through said central flow
31 interelectrode gap at a known rate for a known period of
32 ~~time~~filling said preconcentration cell, with a highly purified
33 ~~form of a fluid of interest;~~
34 applying a known voltage differential across said electrodes
35 exposing the ~~filled~~ preconcentration cell to x-rays; and
36 acquiring data related to a rate at which photons are
37 detected to be emitted from said preconcentration cell~~background~~
38 ~~data related to a rate at which photons are detected to be~~
39 ~~emitted from at least one background data energy channel of said~~
40 ~~preconcentration cell; and~~
41 ~~— associating said background data with said preconcentration~~

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42 | cell.

1 63. (previously presented) The method of claim 62, said step
2 of applying said voltage differential further comprising the step
3 of:

4 applying an electrostatic charge across said electrodes and
5 thereby maintaining ions from said at least one element entrained
6 in said electrodes during transport of said ionic
7 preconcentration cell, using a transportable voltage supply.

1 64. (previously presented) The method of claim 62, further
2 comprising the step of:

3 intimately contacting an upper surface of said upper high
4 surface area electrode with an upper x-ray transmission window of
5 said ionic preconcentration cell.

1 65. (previously presented) The method of claim 64, further
2 comprising the step of:

3 intimately contacting a lower surface of said lower high
4 surface area electrode with a lower x-ray transmission window of
5 said ionic preconcentration cell.

1 66. (original) The method of claim 62, further comprising the
2 steps of:

3 entering a fluid into said ionic preconcentration cell using
4 inlet flow means therefor; and

5 enabling said fluid to flow through said central flow
6 interelectrode gap.

1 67. (previously presented) The method of claim 66, said step
2 of entering said fluid further comprising entering said fluid
3 through said inlet flow means comprising at least one mutually-

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4 planar inlet flow slot substantially coplanar with said central
5 flow interelectrode gap.

1 68. (previously presented) The method of claim 66, said step
2 of entering said fluid further comprising entering said fluid
3 through said inlet flow means comprising a plurality of
4 substantially coplanar inlet flow tubes substantially coplanar
5 with said central flow interelectrode gap and substantially
6 parallel with one another.

1 69. (previously presented) The method of claim 66, further
2 comprising the step of enhancing a turbulence of the flow of said
3 fluid while entering said fluid, thereby inducing mixing of said
4 flow for enabling uniform extraction of said at least one element
5 from the flow stream.

1 70. (previously presented) The method of claim 66, further
2 comprising the step of physically cleaning debris from said inlet
3 flow means using access means for accessing said inlet flow
4 means.

1 71. (original) The method of claim 62, further comprising the
2 step of:

3 exiting said fluid out from said ionic preconcentration cell
4 after said fluid has flowed through said central flow
5 interelectrode gap using outlet flow means therefor.

1 72. (previously presented) The method of claim 71, said step
2 of exiting said fluid further comprising exiting said fluid
3 through said outlet flow means comprising at least one outlet
4 flow slot substantially coplanar with said central flow
5 interelectrode gap.

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1 73. (previously presented) The method of claim 71, said step
2 of exiting said fluid further comprising exiting said fluid
3 through said outlet flow means comprising a plurality of outlet
4 flow tubes substantially coplanar with said central flow
5 interelectrode gap and substantially parallel with one another.

1 74. (previously presented) The method of claim 71, further
2 comprising the step of physically cleaning debris from said
3 outlet flow means using access means for accessing said outlet
4 flow means.

1 75. (previously presented) The method of claim 64, further
2 comprising the step of:

3 maintaining a position of said upper and lower high surface
4 area electrodes and said upper x-ray transmission window relative
5 to one another, using a body of said ionic preconcentration cell
6 comprising a material comprising:
7 substantially no conductivity;
8 resistance to ionic leaching; and
9 resistance to radiation degradation from x-rays to
10 which said preconcentration cell is to be exposed.

1 76. (previously presented) The method of claim 64, further
2 comprising the step of:

3 maintaining a position of said upper and lower high surface
4 area electrodes and said upper x-ray transmission window relative
5 to one another, using a body of said ionic preconcentration cell
6 comprising a material selected from a material group consisting
7 of: plastic, glass, and fiberglass.

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1 77. (previously presented) The method of claim 64, further
2 comprising the step of:

3 maintaining a position of said upper and lower high surface
4 area electrodes and said upper x-ray transmission window relative
5 to one another, using a body of said ionic preconcentration cell
6 comprising a material comprising a non-conducting, machinable
7 polymer substantially resistant to radiation degradation.

1 78. (previously presented) The method of claim 62, further
2 comprising the step of:

3 providing said upper high surface area electrode with an
4 upper electrode thickness thereof less than or equal to
5 approximately $\ell = 1/(\mu * \rho)$, wherein:

6 ℓ designates an optical depth of said upper high surface
7 area electrode when wetted with an element of interest for which
8 a fluidic concentration is to be measured, in said fluid;

9 μ designates a mass absorption coefficient of said upper
10 high surface area electrode, when wetted with said element of
11 interest in said fluid; and

12 ρ designates a material density of said upper high surface
13 area electrode, when wetted with said element of interest in said
14 fluid.

1 79. (previously presented) The method of claim 78, further
2 comprising the step of:

3 providing said lower high surface area electrode with a
4 lower electrode thickness thereof less than or equal to
5 approximately $\ell = 1/(\mu * \rho)$, wherein:

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6 ℓ designates an optical depth of said lower high surface
 7 area electrode when wetted with an element of interest for which
 8 a fluidic concentration is to be measured, in said fluid;

9 μ designates a mass absorption coefficient of said lower
 10 high surface area electrode, when wetted with said element of
 11 interest in said fluid; and

12 ρ designates a material density of said lower high surface
 13 area electrode, when wetted with said element of interest in said
 14 fluid.

1 80. (original) The method of claim 62, further comprising the
 2 step of:

3 providing ordinary surface areas of said upper high surface
 4 area electrode and said lower high surface area electrode
 5 approximately equal to an interrogation spot area of x-rays to
 6 which said preconcentration cell is to be exposed.

1 81. (previously presented) The method of claim 64, further
 2 comprising the step of:

3 providing a surface area of said upper x-ray transmission
 4 window approximately equal to an interrogation spot area of x-
 5 rays to which said preconcentration cell is to be exposed.

1 82. (previously presented) The method of claim 62, further
 2 comprising the step of:

3 providing said central flow interelectrode gap comprising
 4 said predetermined interelectrode gap width, designated d , within
 5 an interelectrode gap range specified by:

$$6 \quad d = \frac{\sigma \Phi w_i}{q \epsilon w_f n_f C F} \times 100\% \approx 2 \times 10^{-9} \frac{\Phi w_i A}{q \epsilon w_f n_f F} \times 100\% \propto \frac{\Phi A}{\epsilon F}; \text{ wherein:}$$

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7 ε designates a predetermined percentage of at least one
8 element of interest to be extracted from said fluid, σ designates
9 a composite conductivity of said fluid, Φ designates said
10 voltage differential applied across said electrodes, $q = 1.60 \times 10^{-19}$
11 Coulomb designates the unit charge, A designates an ordinary
12 surface area covered by said electrodes, n_f designates a number
13 density of said fluid, w_i and w_f designate atomic / molecular
14 weights, respectively, of said at least one element of interest
15 and of said fluid, C designates a concentration of said at least
16 one element of interest in said fluid, and F designates a flow
17 rate of said fluid through said ionic preconcentration cell;
18 said high surface area electrodes further comprise said
19 ordinary surface area A approximately equal to an interrogation
20 spot area of x-rays to which said preconcentration cell is to be
21 exposed;
22 said ε is chosen to be below approximately 5% for said at
23 least one element of interest;
24 said Φ is chosen to be below an electrochemical potential of
25 said at least one element of interest and below an electrolysis
26 potential of said fluid;
27 said F is chosen to exert no more than approximately .1 atm
28 of pressure upon an upper x-ray transmission window of said ionic
29 preconcentration cell in intimate contact with an upper surface
30 of said upper high surface area electrode;
31 said n_f and said w_f are chosen with reference to said at
32 least one element of interest; and
33 said w_i is chosen with reference to said fluid.

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1 83. (previously presented) The method of claim 82, further
2 comprising the step of:
3 providing said central flow interelectrode gap comprising
4 said predetermined interelectrode gap width, d , with:
5 a minimum gap width selected from a minimum gap width group
6 consisting of 2 mm, 1 mm, .5 mm, and .25 mm; and
7 a maximum gap width selected from a maximum gap width group
8 consisting of 2 mm, 5 mm, and 10 mm.

1 84. (previously presented) The method of claim 64, further
2 comprising the step of providing said upper x-ray transmission
3 window comprising:
4 an atomic number below 10;
5 structural rigidity to support up to 1/10 atm. of pressure
6 without bowing more than approximately 100 microns;
7 substantial impermeability relative to said fluid;
8 x-ray transparency greater than 90% for characteristic
9 photon energies from an element of interest for which a fluidic
10 concentration is to be measured;
11 x-ray scattering therefrom minimized to less than
12 approximately 10% of radiation scattered from a column of said
13 fluid equal to one optical depth in said fluid of a
14 characteristic photonic energy from an element of interest for
15 which a fluidic concentration is to be measured; and
16 freedom from any single contaminant in excess of 1 part per
17 million, when measured by x-ray fluorescence.

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- 1 85. (previously presented) The method of claim 65, further
2 comprising the step of providing said lower x-ray transmission
3 window comprising:
4 an atomic number below 10;
5 structural rigidity to support up to 1/10 atm. of pressure
6 without bowing more than approximately 100 microns;
7 substantial impermeability relative to said fluid;
8 x-ray transparency greater than 90% for characteristic
9 photon energies from an element of interest for which a fluidic
10 concentration is to be measured;
11 x-ray scattering therefrom minimized to less than
12 approximately 10% of radiation scattered from a column of said
13 fluid equal to one optical depth in said fluid of a
14 characteristic photonic energy from an element of interest for
15 which a fluidic concentration is to be measured; and
16 freedom from any single contaminant in excess of 1 part per
17 million, when measured by x-ray fluorescence.
- 1 86. (previously presented) The method of claim 64, further
2 comprising the step of:
3 providing said upper x-ray transmission window comprising a
4 polyimide film comprising structural rigidity to support up to
5 1/10 atm. of pressure without bowing more than approximately 100
6 microns.
- 1 87. (previously presented) The method of claim 65, further
2 comprising the step of:
3 providing said lower x-ray transmission window comprising a
4 polyimide film comprising structural rigidity to support up to

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5 1/10 atm. of pressure without bowing more than approximately 100
6 microns.

1 88. (previously presented) The method of claim 62 further
2 comprising the step of:

3 providing said upper high surface area electrode and said
4 lower high surface area electrode each comprising a high surface
5 area material in turn comprising:

6 a large plurality of pores characterized by a specific
7 surface area of at least approximately 100 m²/g;

8 an average pore diameter of said pores between approximately
9 30 nm and 10 nm per pore;

10 a distribution of the pore diameters grouped with a standard
11 deviation of less than approximately 10nm around said average
12 pore diameter;

13 an x-ray transparency greater than approximately 90% for
14 characteristic photon energies from an element of interest for
15 which a fluidic concentration is to be measured;

16 electrical conductivity of 10-40 mOhms-cm when fabricated
17 into a ¼ mm thick electrode;

18 the ability to contain approximately at least 0.1% by weight
19 of foreign material relative to said high surface area material
20 prior to saturation;

21 high structural rigidity wherein a displacement under the
22 flow of said fluid does not exceed approximately 0.25mm;

23 high wetting ability wherein an approximately ¼ mm thick
24 sheet of said high surface area material becomes substantially
25 wetted in less than approximately three seconds; and

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26 freedom from metallic impurities in excess of approximately
27 .5 parts per million, when measured by x-ray fluorescence
28 analysis.

1 89. (previously presented) The method of claim 88, said large
2 plurality of pores characterized by a specific surface area of at
3 least approximately 400 m²/g.

1 90. (previously presented) The method of claim 88, said large
2 plurality of pores characterized by a specific surface area of at
3 most approximately 1000 m²/g.

1 91. (previously presented) The method of claim 89, said large
2 plurality of pores characterized by a specific surface area of at
3 most approximately 1000 m²/g.

1 92. (previously presented) The method of claim 62, further
2 comprising the step of:

3 providing said upper high surface area electrode and said
4 lower high surface area electrode each comprising a high surface
5 area material in turn comprising:

6 an x-ray transparency greater than approximately 90% for
7 characteristic photon energies from an element of interest for
8 which a fluidic concentration is to be measured.

1 93. (original) The method of claim 62, further comprising the
2 step of:

3 providing said upper high surface area electrode and said
4 lower high surface area electrode each comprising a carbon
5 aerogel.

1 94. (previously presented) The method of claim 62, further
2 comprising the step of:

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3 providing said upper high surface area electrode with a
4 thickness less than approximately $\ell = 1/(\mu * p)$; wherein:

5 ℓ designates an optical depth of said upper high surface
6 area electrode when wetted with said fluid;

7 μ designates a mass absorption coefficient of said high
8 surface area electrode when wetted with said fluid; and

9 p designates a density of said high surface area electrode
10 when wetted with said fluid.

1 95. (previously presented) The method of claim 94, further
2 comprising the step of:

3 providing said lower high surface area electrode with a
4 thickness less than approximately $\ell = 1/(\mu * p)$; wherein:

5 ℓ designates an optical depth of said lower high surface
6 area electrode when wetted with said fluid;

7 μ designates a mass absorption coefficient of said lower
8 surface area electrode when wetted with said fluid; and

9 p designates a density of said lower surface area electrode
10 when wetted with said fluid.

1 96. (new) The method of claim 62, further comprising the step
2 of obtaining said calibration data by:

3 filling said preconcentration cell with a highly purified
4 form of a fluid of interest;

5 exposing the filled preconcentration cell to x-rays; and

6 acquiring background data related to a rate at which photons
7 are detected to be emitted from at least one background data
8 energy channel of said preconcentration cell; and

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9 associating said background data with said preconcentration
10 cell.

1 97. (previously presented) The method of claim 62, further
2 comprising the step of obtaining said calibration data by:

3 filling said preconcentration cell, with a first calibration
4 solution containing at least one element of interest in a fluid
5 of interest in known concentration above a minimum detection
6 level of x-ray detection equipment to be used for said detecting
7 and measuring;

8 exposing the filled preconcentration cell to x-rays;

9 acquiring sensitivity data related to a rate at which
10 photons are detected to be emitted from at least one sensitivity
11 data energy channel of said preconcentration cell; and

12 associating said sensitivity data with said preconcentration
13 cell.

1 98. (previously presented) The method of claim 62, further
2 comprising the step of obtaining said calibration data by:

3 applying said voltage differential across the electrodes of
4 said preconcentration cell, below an electrochemical potential of
5 said at least one element of interest and below an electrolysis
6 potential of a calibration solution;

7 flowing said calibration solution containing said at least
8 one element of interest in a fluid of interest in known
9 concentration below a minimum detection level of x-ray detection
10 equipment to be used for said detecting and measuring through the
11 central flow interelectrode gap of said preconcentration cell at
12 a substantially constant flow rate;

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13 exposing said preconcentration cell with said calibration
14 solution therein to x-rays;
15 acquiring ion extraction rate data related to a rate at
16 which photons are detected to be emitted from at least one ion
17 extraction rate data energy channel of said preconcentration
18 cell; and
19 associating said ion extraction rate data with said
20 preconcentration cell.

1 99. (previously presented) The method of claim 62, further
2 comprising the step of obtaining said calibration data by:
3 filling said preconcentration cell, with a highly purified
4 form of a fluid of interest;
5 exposing the filled preconcentration cell to x-rays;
6 acquiring background data related to a rate at which photons
7 are detected to be emitted from at least one background data
8 energy channel of said preconcentration cell;
9 filling said preconcentration cell, with a first calibration
10 solution containing at least one element of interest in said
11 fluid of interest in known concentration above a minimum
12 detection level of x-ray detection equipment to be used for said
13 detecting and measuring;
14 exposing the filled preconcentration cell to x-rays;
15 acquiring sensitivity data related to a rate at which
16 photons are detected to be emitted from at least one sensitivity
17 data energy channel of said preconcentration cell;
18 applying said voltage differential across the electrodes of
19 said preconcentration cell, below an electrochemical potential of

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20 said at least one element of interest and below an electrolysis
21 potential of a second calibration solution;

22 flowing said second calibration solution containing said at
23 least one element of interest in said fluid of interest in known
24 concentration below a minimum detection level of x-ray detection
25 equipment to be used for said detecting and measuring through the
26 central flow interelectrode gap of said preconcentration cell, at
27 a substantially constant flow rate;

28 exposing said preconcentration cell with said second
29 calibration solution therein to x-rays;

30 acquiring ion extraction rate data related to a rate at
31 which photons are detected to be emitted from at least one ion
32 extraction rate data energy channel of said preconcentration
33 cell; and

34 associating said background data, said sensitivity data, and
35 said ion extraction rate data with said preconcentration cell.

1 100. (previously presented) The method of claim 62, further
2 comprising the steps of:

3 applying said voltage differential across said electrodes
4 below an electrochemical potential of said at least one element
5 of interest and below an electrolysis potential of said fluid,
6 suspected to contain at least one element of interest;

7 flowing said fluid through said central flow interelectrode
8 gap at a substantially constant flow rate;

9 exposing said preconcentration cell with said fluid therein
10 to x-rays; and

11 acquiring said test data related to a rate at which photons

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12 are detected to be emitted from at least one test data energy
13 channel of said preconcentration cell.

1 101. (original) The method of claim 100, further comprising
2 the step of:

3 analyzing said test data and deducing therefrom a
4 concentration in said fluid, if any, of the suspected at least
5 one element of interest.

1 102. (previously presented) The method of claim 99, further
2 comprising the steps of:

3 applying said voltage differential across said electrodes
4 below an electrochemical potential of said at least one element
5 of interest and below an electrolysis potential of said fluid,
6 suspected to contain at least one element of interest;

7 flowing said fluid through said central flow interelectrode
8 gap at a substantially constant flow rate;

9 exposing said preconcentration cell with said fluid therein
10 to x-rays; and

11 acquiring said test data related to a rate at which photons
12 are detected to be emitted from at least one test data energy
13 channel of said preconcentration cell.

1 103. (original) The method of claim 102, further comprising
2 the step of:

3 analyzing said test data in relation to said background
4 data, said sensitivity data, and said ion extraction rate data,
5 and deducing therefrom a concentration in said fluid, if any, of
6 the suspected at least one element of interest.

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1 104. (previously presented) The method of claim 62, further
2 comprising the step of:

3 exposing said preconcentration cell to x-rays substantially
4 transmitted through said upper x-ray transmission window, while
5 flowing said fluid and while applying said voltage differential.

1 105. (previously presented) The method of claim 62, said step
2 of applying said voltage differential further comprising the
3 steps of:

4 ceasing flow of said fluid while applying an electrostatic
5 charge across said electrodes and thereby maintaining ions from
6 said at least one element entrained in said electrodes;

7 transporting said ionic preconcentration cell to an x-ray
8 source means for emitting x-rays toward said preconcentration
9 cell while applying said electrostatic charge; and

10 exposing said preconcentration cell to x-rays from said x-
11 ray source means while applying said electrostatic charge.

1 106. (previously presented) The method of claim 62, further
2 comprising the step of:

3 controlling a flow rate of said fluid through said ionic
4 preconcentration cell so as to maintain ϵ , which designates a
5 predetermined percentage of at least one element of interest to
6 be extracted from said fluid, below approximately 5% for said at
7 least one element of interest.

1 107. (previously presented) The method of claim 106, further
2 comprising the step of:

3 maintaining said ϵ below an extraction percentage selected
4 from an extraction percentage group consisting of approximately

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5 4%, 3%, 2%, and 1%.

1 108. (previously presented) The method of claim 62, further
2 comprising the step of:

3 controlling a flow rate F of said fluid through said ionic
4 preconcentration cell and maintaining said F at a substantially
5 constant level so as to maintain ε , which designates a
6 predetermined percentage of at least one element of interest to
7 be extracted from said fluid and is specified by:

8
$$\varepsilon = \frac{\Gamma_{ie}}{\Gamma_{is}} = \frac{\sigma \Phi w_i}{q d w_f n_f C F} \times 100\%,$$

9 below approximately 5% for said at least one element of interest;
10 wherein:

11 Γ_{ie} and Γ_{is} designate rates at which ions of said at least
12 one element of interest are respectively extracted from said
13 fluid by said cell and supplied to said cell by said fluid, σ
14 designates a composite conductivity of said fluid, Φ designates
15 said voltage differential applied across said electrodes, d
16 designates said predetermined interelectrode gap width of said
17 central flow interelectrode gap, $q = 1.60 \times 10^{-19}$ Coulomb designates
18 the unit charge, A designates an ordinary surface area covered by
19 said electrodes, n_f designates a number density of said fluid,
20 w_i and w_f designate atomic / molecular weights, respectively, of
21 said at least one element of interest and of said fluid, and C
22 designates a concentration of said at least one element of
23 interest in said fluid; and

24 having said concentration C in a range where conductivity
25 varies substantially linearly with concentration, with C in units

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26 of parts per billion, wherein σ is approximated by:

27 $\sigma \approx 2 \times 10^{-9} C / \text{Ohm-cm}.$

1 109. (previously presented) The method of claim 108, further
2 comprising the step of:

3 maintaining said ϵ below an extraction percentage selected
4 from an extraction percentage group consisting of approximately
5 4%, 3%, 2%, and 1%.

1 110. (original) The method of claim 62, further comprising the
2 step of:

3 applying said voltage differential across said electrodes
4 below an electrochemical potential of at least one element of
5 interest and below an electrolysis potential of said fluid.

1 111. (previously presented) The method of claim 62, further
2 comprising the step of:

3 monitoring a total non-saturated concentration of dissolved
4 ions in said upper and lower high surface area electrodes, by
5 monitoring a leakage current from said cell.

1 112. (previously presented) The method of claim 111, further
2 comprising the step of:

3 measuring at least one element of interest comprising ultra-
4 low trace, high valence ions in said fluid, based on said
5 detecting the non-saturated saturation state.

1 113. (element of interest) The method of claim 62, further
2 comprising the steps of:

3 monitoring a total non-saturated concentration of dissolved
4 ions in said upper and lower high surface area electrodes by
5 monitoring a leakage current in said cell; and

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6 adjusting the flow of said fluid through said ionic
7 preconcentration cell to control a percentage of said ions
8 extracted from said fluid, based on said monitoring of said
9 leakage current.

1 114. (previously presented) The method of claim 62, further
2 comprising the steps of:

3 setting an impurity concentration C , in a range where
4 conductivity varies substantially linearly with concentration, to
5 a predetermined desired concentration detection level; and

6 controlling how long said fluid flows through said ionic
7 preconcentration cell by flowing said fluid for a time t given
8 by:

9
$$t \propto \frac{S\ell}{\sigma} \propto \frac{S\ell}{C}, \text{ wherein:}$$

10 S designates a sensitivity of x-ray detection equipment to
11 be used for said detecting and measuring;

12 ℓ designates a thickness of said upper high surface area
13 electrode; and

14 σ designates a composite conductivity of said fluid.

1 115. (previously presented) The method of claim 62, further
2 comprising the step of:

3 triggering an action in response to detecting that a
4 concentration of at least one element of interest in said fluid
5 has passed a predetermined, non-saturated threshold
6 concentration.

1 116. (previously presented) The method of claim 115, said step
2 of triggering further comprising the step of:

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3 maintaining said concentration within a predetermined
4 concentration range by injecting at least one element into said
5 fluid as said action in response to said detecting.

1 117. (previously presented) The method of claim 115, said step
2 of triggering further comprising the step of:

3 maintaining said concentration within a predetermined
4 concentration range by diluting at least one diluting fluid into
5 said fluid as said action in response to said detecting.

1 118. (previously presented) The method of claim 62, further
2 comprising the step of:

3 cleaning said preconcentration cell after use by releasing
4 ions accumulated within said high specific surface area of said
5 electrodes into said fluid, after the accumulated ions have been
6 exposed to x-rays and fluorescence from said preconcentration
7 cell has been detected.

1 119. (previously presented) The method of claim 64, further
2 comprising the steps of:

3 emitting x-rays toward said preconcentration cell
4 substantially transmitted through said upper x-ray transmission
5 window; and

6 detecting fluoresced energy emitted by said preconcentration
7 cell due to said emitting x-rays toward said preconcentration
8 cell, through said upper x-ray transmission window.

1 120. (previously presented) The method of claim 119, further
2 comprising the step of:

3 analyzing the detected x-ray fluoresced energy and deducing
4 therefrom a concentration in said fluid of at least one element

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5 of interest in said fluid.

1 121. (previously presented) The method of claim 62, further
2 comprising the step of:

3 downloading and analyzing said test data from said ionic
4 preconcentration cell using a telecommunications link.

1 122. (previously presented) The system of claim 3, wherein:

2 said transportable voltage supply is embedded into a body of
3 said ionic preconcentration cell.

1 123. (previously presented) The method of claim 63, further
2 comprising the step of:

3 providing said transportable voltage supply embedded into a
4 body of said ionic preconcentration cell.

1 124-138. (cancelled)

1 139. (previously presented) An ionic preconcentration cell
2 apparatus for identifying and measuring concentrations of
3 elements in fluids, comprising:

4 an upper high surface area electrode comprising a high
5 specific surface area thereof;

6 a lower high surface area electrode comprising a high
7 specific surface area thereof, substantially parallel to said
8 upper high surface area electrode;

9 a central flow interelectrode gap separating said upper and
10 lower high surface area electrodes by a predetermined
11 interelectrode gap width;

12 fluid flow means for flowing a fluid through said central
13 flow interelectrode gap; and

14 an upper x-ray transmission window in intimate contact with

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15 an upper surface of said upper high surface area electrode; said
16 upper x-ray transmission window comprising:
17 an atomic number below 10;
18 structural rigidity to support up to 1/10 atm. of pressure
19 without bowing more than approximately 100 microns;
20 substantial impermeability relative to said fluid;
21 x-ray transparency greater than 90% for characteristic
22 photon energies from an element of interest for which a fluidic
23 concentration is to be measured;
24 x-ray scattering therefrom minimized to less than
25 approximately 10% of radiation scattered from a column of said
26 fluid equal to one optical depth in said fluid of a
27 characteristic photonic energy from an element of interest for
28 which a fluidic concentration is to be measured; and
29 freedom from any single contaminant in excess of 1 part per
30 million, when measured by x-ray fluorescence.

1 140. (previously presented) An ionic preconcentration cell
2 apparatus for identifying and measuring concentrations of
3 elements in fluids, comprising:
4 an upper high surface area electrode comprising a high
5 specific surface area thereof;
6 a lower high surface area electrode comprising a high
7 specific surface area thereof, substantially parallel to said
8 upper high surface area electrode;
9 a central flow interelectrode gap separating said upper and
10 lower high surface area electrodes by a predetermined
11 interelectrode gap width;

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12 fluid flow means for flowing a fluid through said central
13 flow interelectrode gap;
14 an upper x-ray transmission window in intimate contact with
15 an upper surface of said upper high surface area electrode; and
16 a lower x-ray transmission window in intimate contact with a
17 lower surface of said lower high surface area electrode; said
18 lower x-ray transmission window comprising:
19 an atomic number below 10;
20 structural rigidity to support up to 1/10 atm. of pressure
21 without bowing more than approximately 100 microns;
22 substantial impermeability relative to said fluid;
23 x-ray transparency greater than 90% for characteristic
24 photon energies from an element of interest for which a fluidic
25 concentration is to be measured;
26 x-ray scattering therefrom minimized to less than
27 approximately 10% of radiation scattered from a column of said
28 fluid equal to one optical depth in said fluid of a
29 characteristic photonic energy from an element of interest for
30 which a fluidic concentration is to be measured; and
31 freedom from any single contaminant in excess of 1 part per
32 million, when measured by x-ray fluorescence.

1 141-156. (cancelled)

1 157. (previously presented) A method for identifying and
2 measuring concentrations of elements in fluids, comprising the
3 steps of:

4 flowing a fluid through a central flow interelectrode gap of
5 an ionic preconcentration cell separating an upper high specific

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6 surface area electrode from a lower high specific surface area
7 electrode of said ionic preconcentration cell by a predetermined
8 interelectrode gap width;
9 applying a voltage differential between said upper high
10 surface area electrode and said lower high surface area electrode
11 while said fluid is flowing through said central flow
12 interelectrode gap;
13 passing x-rays through an upper x-ray transmission window
14 intimately contacting an upper surface of said upper high surface
15 area electrode;
16 deducing an identity, or measurement of concentration, of at
17 least one element in said fluid based on a response of said
18 preconcentration cell to said x-rays; and
19 providing said upper x-ray transmission window comprising:
20 an atomic number below 10;
21 structural rigidity to support up to 1/10 atm. of pressure
22 without bowing more than approximately 100 microns;
23 substantial impermeability relative to said fluid;
24 x-ray transparency greater than 90% for characteristic
25 photon energies from an element of interest for which a fluidic
26 concentration is to be measured by said method;
27 x-ray scattering therefrom minimized to less than
28 approximately 10% of radiation scattered from a column of said
29 fluid equal to one optical depth in said fluid of a
30 characteristic photonic energy from an element of interest for
31 which a fluidic concentration is to be measured by said method;
32 and

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33 freedom from any single contaminant in excess of 1 part per
34 million, when measured by x-ray fluorescence.

1 158. (previously presented) A method for identifying and
2 measuring concentrations of elements in fluids, comprising the
3 steps of:

4 flowing a fluid through a central flow interelectrode gap of
5 an ionic preconcentration cell separating an upper high specific
6 surface area electrode from a lower high specific surface area
7 electrode of said ionic preconcentration cell by a predetermined
8 interelectrode gap width;

9 applying a voltage differential between said upper high
10 surface area electrode and said lower high surface area electrode
11 while said fluid is flowing through said central flow
12 interelectrode gap;

13 passing x-rays through an upper x-ray transmission window
14 intimately contacting an upper surface of said upper high surface
15 area electrode;

16 deducing an identity, or measurement of concentration, of at
17 least one element in said fluid based on a response of said
18 preconcentration cell to said x-rays;

19 passing said x-rays through a lower x-ray transmission
20 window intimately contacting a lower surface of said lower high
21 surface area electrode; and

22 providing said lower x-ray transmission window comprising:
23 an atomic number below 10;

24 structural rigidity to support up to 1/10 atm. of pressure
25 without bowing more than approximately 100 microns;

26 substantial impermeability relative to said fluid;
 27 x-ray transparency greater than 90% for characteristic
 28 photon energies from an element of interest for which a fluidic
 29 concentration is to be measured by said method;

30 x-ray scattering therefrom minimized to less than
 31 approximately 10% of radiation scattered from a column of said
 32 fluid equal to one optical depth in said fluid of a
 33 characteristic photonic energy from an element of interest for
 34 which a fluidic concentration is to be measured by said method;
 35 and

36 freedom from any single contaminant in excess of 1 part per
 37 million, when measured by x-ray fluorescence.

1 159-160. (cancelled)

1 161. (previously presented) A method of optimizing fabrication
 2 of an ionic preconcentration cell for identifying and measuring
 3 concentrations of elements in fluids; said ionic preconcentration
 4 cell comprising an upper high surface area electrode comprising a
 5 high specific surface area thereof; a lower high surface area
 6 electrode comprising a high specific surface area thereof; and a
 7 central flow interelectrode gap separating said upper and lower
 8 high surface area electrodes by a predetermined interelectrode
 9 gap width; said method comprising the step of:

10 optimizing said upper high surface area electrode with an
 11 upper electrode thickness less than or equal to approximately an
 12 optical depth ℓ of said upper high surface area electrode when
 13 wetted with a fluid to be flowed through said cell.

1 162. (previously presented) The optimization method of claim

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2 161, wherein:

3 said $\ell = 1/(\mu * \rho)$; and wherein:

4 μ designates a mass absorption coefficient of said upper
5 high surface area electrode when wetted with said fluid; and

6 ρ designates a material density of said upper high surface
7 area electrode when wetted with said fluid.

1 163. (previously presented) The optimization method of claim
2 161, further comprising the step of:

3 optimizing said lower high surface area electrode with a
4 lower electrode thickness less than or equal to approximately an
5 optical depth ℓ of said lower high surface area electrode when
6 wetted with said fluid.

1 164. (previously presented) The optimization method of claim
2 163, wherein:

3 said $\ell = 1/(\mu * \rho)$; and wherein:

4 μ designates a mass absorption coefficient of said lower
5 high surface area electrode when wetted with said fluid; and

6 ρ designates a material density of said lower high surface
7 area electrode when wetted with said fluid.

1 165. (previously presented) A method of optimizing fabrication
2 of an ionic preconcentration cell for identifying and measuring
3 concentrations of elements in fluids; said ionic preconcentration
4 cell comprising an upper high surface area electrode comprising a
5 high specific surface area thereof; a lower high surface area
6 electrode comprising a high specific surface area thereof; and a
7 central flow interelectrode gap separating said upper and lower

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8 high surface area electrodes by a predetermined interelectrode
9 gap width; said method comprising the step of:
10 optimizing said upper high surface area electrode with an
11 upper electrode thickness less than or equal to approximately an
12 optical depth ℓ of said upper high surface area electrode when
13 wetted with an element of interest for which a fluidic
14 concentration is to be measured by said cell, in a fluid to be
15 flowed through said cell.

1 166. (previously presented) The optimization method of claim
2 165, wherein:

3 said $\ell = 1/(\mu * \rho)$; and wherein:

4 μ designates a mass absorption coefficient of said upper
5 high surface area electrode when wetted with said element of
6 interest in said fluid; and

7 ρ designates a material density of said upper high surface
8 area electrode when wetted with said element of interest in said
9 fluid.

1 167. (previously presented) The optimization method of claim
2 165, further comprising the step of:

3 optimizing said lower high surface area electrode with a
4 lower electrode thickness less than or equal to approximately an
5 optical depth ℓ of said lower high surface area electrode when
6 wetted with said element of interest, in said fluid.

1 168. (previously presented) The optimization method of claim
2 167, wherein:

3 said $\ell = 1/(\mu * \rho)$; and wherein:

μ designates a mass absorption coefficient of said lower high surface area electrode when wetted with said element of interest in said fluid; and

ρ designates a material density of said lower high surface area electrode when wetted with said element of interest in said fluid.

169-176. (cancelled)

177. (previously presented) A method of optimizing fabrication of an ionic preconcentration cell for identifying and measuring concentrations of elements in fluids; said ionic preconcentration cell comprising an upper high surface area electrode comprising a high specific surface area thereof; a lower high surface area electrode comprising a high specific surface area thereof; and a central flow interelectrode gap separating said upper and lower high surface area electrodes by a predetermined interelectrode gap width; said method comprising the step of:

optimizing said central flow interelectrode gap comprising said predetermined interelectrode gap width, designated d , within an interelectrode gap range specified by:

$$d = \frac{\sigma \Phi w_i A}{q \epsilon w_f n_f C F} \times 100\% \approx 2 \times 10^{-9} \frac{\Phi w_i A}{q \epsilon w_f n_f F} \times 100\% \propto \frac{\Phi A}{d^2}; \text{ wherein:}$$

ϵ designates a predetermined percentage of at least one element of interest to be extracted from a fluid to be flowed through said cell, σ designates a composite conductivity of said fluid, Φ designates a voltage differential applied across said electrodes, $q = 1.60 \times 10^{-19}$ Coulomb designates the unit charge, A

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19 designates an ordinary surface area covered by said electrodes,
20 n_f designates a number density of said fluid, w_i and w_f designate
21 atomic / molecular weights, respectively, of said at least one
22 element of interest and of said fluid, C designates a
23 concentration of said at least one element of interest in said
24 fluid, and F designates a flow rate of said fluid through said
25 ionic preconcentration cell;

26 said high surface area electrodes further comprise said
27 ordinary surface area A approximately equal to an interrogation
28 spot area of x-rays to which said preconcentration cell is to be
29 exposed;

30 said ε is chosen to be below approximately 5% for said at
31 least one element of interest;

32 said Φ is chosen to be below an electrochemical potential of
33 said at least one element of interest and below an electrolysis
34 potential of said fluid;

35 said F is chosen to exert no more than approximately .1 atm
36 of pressure upon an upper x-ray transmission window of said ionic
37 preconcentration cell in intimate contact with an upper surface
38 of said upper high surface area electrode;

39 said n_f and said w_f are chosen with reference to said at
40 least one element of interest; and

41 said w_i is chosen with reference to said fluid.

1 178. (previously presented) The optimization method of claim
2 177, wherein:

3 as a consequence of said optimizing, said central flow
4 interelectrode gap comprises said predetermined interelectrode

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5 gap width, d , with:

6 a minimum gap width selected from a minimum gap width group
7 consisting of 2 mm, 1 mm, .5 mm, and .25 mm; and

8 a maximum gap width selected from a maximum gap width group
9 consisting of 2 mm, 5 mm, and 10 mm.

1 179-190 (cancelled)

1 191. (previously presented) An ionic preconcentration cell
2 apparatus for identifying and measuring concentrations of
3 elements in fluids, comprising:

4 an upper high surface area electrode comprising a high
5 specific surface area thereof;

6 a lower high surface area electrode comprising a high
7 specific surface area thereof, substantially parallel to said
8 upper high surface area electrode;

9 a central flow interelectrode gap separating said upper and
10 lower high surface area electrodes by a predetermined
11 interelectrode gap width;

12 fluid flow means for flowing a fluid through said central
13 flow interelectrode gap; and

14 flow control means for controlling a flow rate of said fluid
15 through said ionic preconcentration cell so as to maintain ε ,
16 which designates a predetermined percentage of at least one
17 element of interest to be extracted from said fluid, below
18 approximately 5% for said at least one element of interest.

1 192. (previously presented) The apparatus of claim 191,
2 wherein said ε is maintained below an extraction percentage

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3 selected from an extraction percentage group consisting of
4 approximately 4%, 3%, 2%, and 1%.

1 193. (previously presented) The apparatus of claim 191,
2 further comprising:

3 voltage application means for applying a voltage
4 differential between said upper high surface area electrode and
5 said lower high surface area electrode while said fluid is
6 flowing through said central flow interelectrode gap; and
7 said flow control means for controlling said flow rate F of
8 said fluid through said ionic preconcentration cell and
9 maintaining said F at a substantially constant level so as to
10 maintain said ε , which is specified by:

11
$$\varepsilon = \frac{\Gamma_{ie}}{\Gamma_{is}} = \frac{\sigma \Phi w_i}{qd w_f n_f C F} \times 100\%,$$

12 below approximately 5% for said at least one element of interest;
13 wherein:

14 Γ_{ie} and Γ_{is} designate rates at which ions of said at least
15 one element of interest are respectively extracted from said
16 fluid by said cell and supplied to said cell by said fluid, σ
17 designates a composite conductivity of said fluid, Φ designates
18 a potential applied by said voltage application means across said
19 electrodes, d designates said predetermined interelectrode gap
20 width of said central flow interelectrode gap, $q = 1.60 \times 10^{-19}$
21 Coulomb designates the unit charge, A designates an ordinary
22 surface area covered by said electrodes, n_f designates a number
23 density of said fluid, w_i and w_f designate atomic / molecular
24 weights, respectively, of said at least one element of interest

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25 and of said fluid, and C designates a concentration of said at
26 least one element of interest in said fluid; and
27 for having said concentration C in a range where
28 conductivity varies substantially linearly with concentration,
29 with C in units of parts per billion, wherein σ is approximated
30 by:

31
$$\sigma \approx 2 \times 10^{-9} C / \text{Ohm} - \text{cm} .$$

1 194. (previously presented) The apparatus of claim 193,
2 wherein said ϵ is maintained below an extraction percentage
3 selected from an extraction percentage group consisting of
4 approximately 4%, 3%, 2%, and 1%.

1 195. (previously presented) A method for identifying and
2 measuring concentrations of elements in fluids, comprising the
3 steps of:

4 flowing a fluid through a central flow interelectrode gap of
5 an ionic preconcentration cell separating an upper high specific
6 surface area electrode from a lower high specific surface area
7 electrode of said ionic preconcentration cell by a predetermined
8 interelectrode gap width;

9 applying a voltage differential between said upper high
10 surface area electrode and said lower high surface area electrode
11 while said fluid is flowing through said central flow
12 interelectrode gap;

13 exposing said cell to x-rays;

14 deducing an identity, or measurement of concentration, of at
15 least one element in said fluid based on a response of said
16 preconcentration cell to said x-rays; and

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17 controlling a flow rate of said fluid through said ionic
18 preconcentration cell so as to maintain ε , which designates a
19 predetermined percentage of at least one element of interest to
20 be extracted from said fluid, below approximately 5% for said at
21 least one element of interest.

1 196. (previously presented) The method of claim 195, further
2 comprising the step of:

3 maintaining said ε below an extraction percentage selected
4 from an extraction percentage group consisting of approximately
5 4%, 3%, 2%, and 1%.

1 197. (previously presented) The method of claim 195, said step
2 of controlling said flow rate further comprising the step of:

3 controlling said flow rate F of said fluid through said
4 ionic preconcentration cell and maintaining said F at a
5 substantially constant level so as to maintain said ε , which is
6 specified by:

7
$$\varepsilon = \frac{\Gamma_{ie}}{\Gamma_{is}} = \frac{\sigma \Phi w_i}{qd w_f n_f CF} \times 100\%,$$

8 below approximately 5% for said at least one element of interest;
9 wherein:

10 Γ_{ie} and Γ_{is} designate rates at which ions of said at least
11 one element of interest are respectively extracted from said
12 fluid by said cell and supplied to said cell by said fluid, σ
13 designates a composite conductivity of said fluid, Φ designates
14 said voltage differential applied across said electrodes, d
15 designates said predetermined interelectrode gap width of said
16 central flow interelectrode gap, $q = 1.60 \times 10^{-19}$ Coulomb designates

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17 the unit charge, A designates an ordinary surface area covered by
18 said electrodes, n_f designates a number density of said fluid,
19 w_i and w_f designate atomic / molecular weights, respectively, of
20 said at least one element of interest and of said fluid, and C
21 designates a concentration of said at least one element of
22 interest in said fluid; and

23 having said concentration C in a range where conductivity
24 varies substantially linearly with concentration, with C in units
25 of parts per billion, wherein σ is approximated by:

26
$$\sigma \approx 2 \times 10^{-9} C / \text{Ohm} - \text{cm} .$$

1 198. (previously presented) The method of claim 197, further
2 comprising the step of:

3 maintaining said ϵ below an extraction percentage selected
4 from an extraction percentage group consisting of approximately
5 4%, 3%, 2%, and 1%.

1 199. (previously presented) An ionic preconcentration cell
2 apparatus for identifying and measuring concentrations of
3 elements in fluids, comprising:

4 an upper high surface area electrode comprising a high
5 specific surface area thereof;

6 a lower high surface area electrode comprising a high
7 specific surface area thereof, substantially parallel to said
8 upper high surface area electrode;

9 a central flow interelectrode gap separating said upper and
10 lower high surface area electrodes by a predetermined
11 interelectrode gap width;

12 fluid flow means for flowing a fluid through said central

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13 flow interelectrode gap; and
14 time control means for controlling how long said fluid flows
15 through said ionic preconcentration cell based on setting an
16 impurity concentration C , in a range where conductivity varies
17 substantially linearly with concentration, to a predetermined
18 desired concentration detection level and flowing said fluid for
19 a time t given by:

20
$$t \propto \frac{S\ell}{\sigma} \propto \frac{S\ell}{C}; \text{ wherein:}$$

21 S designates a sensitivity of x-ray detection equipment to
22 be used for said detecting and measuring;

23 ℓ designates a thickness of said upper high surface area
24 electrode; and

25 σ designates a composite conductivity of said fluid.

1 200. (previously presented) A method for identifying and
2 measuring concentrations of elements in fluids, comprising the
3 steps of:

4 flowing a fluid through a central flow interelectrode gap of
5 an ionic preconcentration cell separating an upper high specific
6 surface area electrode from a lower high specific surface area
7 electrode of said ionic preconcentration cell by a predetermined
8 interelectrode gap width;

9 applying a voltage differential between said upper high
10 surface area electrode and said lower high surface area electrode
11 while said fluid is flowing through said central flow
12 interelectrode gap;

13 exposing said cell to x-rays;

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14 deducing an identity, or measurement of concentration, of at
15 least one element in said fluid based on a response of said
16 preconcentration cell to said x-rays;

17 setting an impurity concentration C , in a range where
18 conductivity varies substantially linearly with concentration, to
19 a predetermined desired concentration detection level; and

20 controlling how long said fluid flows through said ionic
21 preconcentration cell by flowing said fluid for a time t given
22 by:

23 $t \propto \frac{S\ell}{\sigma} \propto \frac{S\ell}{C}$, wherein:

24 S designates a sensitivity of x-ray detection equipment to
25 be used for said identifying and measuring;

26 ℓ designates a thickness of said upper high surface area
27 electrode; and

28 σ designates a composite conductivity of said fluid.